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Vol. 28. No. 220. April 1942.

THE PRESERVATION OF TIMBER.*

By R. L. Brooks
(Conservator of Forests, Trinidad).

Introduction.

During 1940 approximately 1,000,000 cubic feet of local timber (excluding corduroy and firewood), and a further 1,829,000 cubic feet of imported timber, were utilized in Trinidad, whilst a further estimated 1,400,000 cubic feet of local wood were cut by petroleum companies and not used. There is every reason to believe that the consumption for 1941 will be even greater, especially in view of the restrictions on steel.

Such a large consumption of local wood, which is nearly double that of normal years, constitutes a considerable drain on available supplies, especially of the more popular species. The even larger consumption of imported wood represents a considerable expenditure of dollar currency and the use of a considerable amount of shipping. By no means all of this consumption is represented by new works: a large portion of it goes to replacements and repairs, although figures of the relative proportions are not available.

No one can foresee how long the present crisis will last, nor whether throughout the crisis there will be available ample supplies of timber from the U.S.A. and Canada and ships in which to carry them. It is our bounden duty, therefore, to avoid waste of timber from whatever source, and we can do this only by the adoption of appropriate measures, at present almost non-existent in the Colony, to prolong to the utmost the life of all the timber that we use, and to enable the use in one form or another of species of timber which we have despised in the past and allowed to rot unused on the ground.

The decay and destruction of timber can, even in the tropics, be very considerably retarded by the adoption of certain practical constructional methods and by the use, where indicated, of timber treated with preservatives. The former measures involve little, if any, increase in expenditure; the latter must inevitably increase the first cost of the timber, but if intelligent methods are used according to the relative dangers to which timbers of various types are to be exposed, the increased cost is more than offset by the increased life of the timber.

Before considering remedial measures, however, it is of the utmost importance to have a basic knowledge of the kinds and habits of the pests which cause decay and destruction in timber, since remedial measures ignorantly and unintelligently applied cause waste of money and often complete failure. The enemies of timber on land are fungi and insects, and in the sea marine borers.

Fungi.

Fungi represent a low form of plant life, which does not possess the green colouring-matter (chlorophyll) by which other plants, with the help of sunlight, are able to build up the greater part of their food materials from

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the carbon dioxide in the air; consequently fungi are forced to obtain their organic food from supplies in dead or living plants and animals.

The main body of the fungus, known as the mycelium, is built up of a mass of fine threads or hyphæ: these hyphæ, in the case of wood-destroying fungi, permeate the wood cells and are able to digest the wood substances, which are mainly composed of material easily converted to sugar.

The fruiting body of the fungus, which is in most cases the conspicuous part, is usually formed only after a large amount of mycelium has been formed. These fruiting bodies, which are formed in the open, produce enormous numbers of microscopic spores: it has been estimated that the fruiting body of a dry-rot fungus a foot square can throw off some 5 million spores per minute for a period of several days. These spores, of course, function as seeds, and as a result of their immense numbers it is clearly impossible for any piece of wood in the open not to come into contact with spores sooner or later.

Fortunately, however, for timber generally fungi require certain conditions for their growth: these are as follows:—

(*a*) *Suitable Food Material.*—Not all timbers provide a suitable food material for fungi: for example, such well-known local woods as balata and poui prove resistant to fungi. Again, the heart-wood of all species of timber provides a less suitable food material than the sapwood, and is consequently more resistant. Certain fungi are so highly specialized that they will attack only one species of wood; other destructive fungi are unable to attack absolutely sound wood, but will readily attack wood already infected by some other fungus.

(*b*) *Adequate Supply of Air.*—Fungi require oxygen for their respiration, and are unable to grow in the absence of air: that is why timber which is permanently submerged under water cannot be attacked by fungi.

(*c*) *Adequate Supply of Moisture.*—Fungi require moisture for their growth, and grow most vigorously under very damp conditions. It is a most heartening fact that fungi cannot grow in timber which contains less than 20 per cent. moisture, based on its oven-dry weight. This is a most important fact to remember in connection with the use of timber in buildings.

(*d*) *Satisfactory Temperature.*—The optimum temperature for fungi is about 80–90° F.: high temperatures are lethal to fungi, whilst growth stops entirely at low temperatures a little above freezing point.

Especially ideal conditions for the development of wood-destroying fungi, in the shape of an abundant supply of moisture and stagnant air, are present in the case of wood in contact with the ground. Similarly, cracks developing in wood in the open collect and harbour moisture and form a satisfactory starting-point of attack by fungi.

Insects.

1. *Termites.*

Termites are the insects most destructive to timber in Trinidad, although their attacks are not so severe as in many other countries, and they are not

responsible for so much damage to timber in contact with the ground as are fungi.

Termites, commonly called white ants or, locally, wood-lice, are social insects living in colonies and dividing their work among specialized castes: each colony lives shut off from the outside world and with no interconnection with other colonies. They feed on cellulose materials and attack many other kinds of material; their intestines contain large numbers of Protozoa, which presumably aid in digesting the food, and without which the termite cannot live. An important habit with reference to their control is the constant licking of their own bodies and of the bodies of other members of the community.

Wood-destroying termites in Trinidad may be divided into two main classes: dry-wood termites and subterranean termites.

(1) *Dry-wood Termites.*—These are confined entirely to wood, living in dry, sound wood of trees, poles, posts, buildings, furniture, etc.; they do not enter the ground, and the common species require no water supply. There are only two forms—soldiers and reproductives; the latter periodically develop wings and emerge into the open. These alates (locally known as rain-flies) find themselves mates and, after dropping their wings, eat their way into some piece of wood, plugging up their entrance hole after them, and found a new colony. Dry-wood termites attack the woodwork of buildings and furniture: their presence can be detected by the extruded small fæcal pellets, of uniform size and shape and about the size of pins' heads. The commonest and most destructive species in Trinidad is *Cryptotermes brevis*.

(2) *Subterranean Termites.*—These termites live partly or almost entirely in the ground, and it is essential for them always to maintain a connection with the ground, as it is from this source that they derive their moisture. All termites working in a structure above ground will die if their connection with the ground is permanently severed. They attack wood in or on the ground, or build covered runways to reach wood above the ground; these runways are composed of particles of earth and partly digested wood, and form the essential link with the soil. Subterranean termites have three forms—reproductives, soldiers, and workers; the reproductives develop wings, as in the case of the dry-wood termites, mate, and found new colonies. Subterranean termites never produce the fæcal pellets characteristic of the dry-wood termites: their work can be recognized by the presence of a "frass" composed of earth particles, wood fragments, debris, etc., cemented together by saliva and fæcal deposits, which is used to plug up unused galleries or openings. External attack can also, of course, be recognized by the characteristic tubes. The two commonest genera of subterranean termites are *Heterotermes* and *Coptotermes*, of which the former is by far the most destructive to houses.

2. *Powder-Post Beetles* (*Lyctidæ*).

The larvæ of the powder-post beetles do a considerable amount of damage to timber in houses and furniture. The adult beetle is small,

about $\frac{1}{16}$ inch in length; it lays its eggs in the wood, and the burrowing larvæ are capable of reducing the wood to a fine powder. The extrusion of this fine powder—quite distinctive from the pellets of the dry-wood termite or the "frass" of the subterranean termite—indicates the presence of attack. Sapwood is far more susceptible to attack that heartwood.

3. *Other Insects.*

There are other insects, such as the Bostrychidæ (another form of powder-post beetle) and Cerambycidæ or Longhorns, which are responsible for the destruction of timber, mainly sapwood, but these are of relatively minor importance, and preventive measures are the same as those for dry-wood termites.

Preventive Measures.

From the foregoing very brief outline of the types and habits of the principal agents of destruction and decay of timber, it is clear that their varying habits and mode of life mean the adoption of a variety of common-sense preventive measures; certain measures, for example, designed to ward off the subterranean termites are quite useless as a protection against the dry-wood termite.

Preventive Measures against Fungus Attack.

In considering adequate measures for the prevention of fungus attack, the following material facts must be borne in mind :—

(*a*) That heat, air, and moisture are necessary for the development of fungi.

(*b*) That a great excess of any of these is deleterious to fungi.

(*c*) That, generally speaking, softwoods are more liable to attack than hardwoods, and sapwood than heartwood.

The following are the main preventive measures which should be generally adopted :—

1. *Timbers in Contact with the Ground:* e.g., *Posts, Poles and Wooden Foundations of Buildings.*

(*a*) Use only all-heart timbers of proved resistance to fungus attack (*vide* table in Appendix I).

(*b*) Use timber which has been properly treated with an effective preservative.

2. *Timbers not in Contact with the Ground:* e.g., *House Timbers.*

(1) *Selection of Timber.*

(*a*) Use only seasoned timber, and protect such timber against subsequent dampness prior to use: fungus cannot grow on timber with a moisture content of 20 per cent. or less.

(*b*) If the timber is to be exposed, and at all danger points where there may be access to moisture or poor air circulation, use only heartwood of timber of proved resistance, or treated wood.

(*c*) Do not use timber which already shows any signs of fungus attack.

(2) *Construction Measures.*

(*a*) Take every precaution to avoid access of moisture to the timber. In other than timber-frame houses adequate damp-proofing is essential where timber comes into contact with other materials of construction, which are introduced in a wet state or which themselves are not damp-proof.

(*b*) Avoid any danger of condensation of moisture on the internal surfaces of walls, which may start fungus growth behind skirting-boards, etc.

(*c*) Ensure, so far as is possible—*e.g.*, in the case of wood floors—adequate air circulation.

(*d*) In the case of wood floors laid on concrete, construct an upper thin layer of impermeable concrete, and cover the concrete after it has dried with a thick, damp-proof, bituminous coat.

(*e*) Do not allow the use of linoleum over wood flooring which is laid direct to concrete, until the house has had time to dry out. At any time the use of a covering over the *whole* floor area, which prevents the access of air and, when washed, allows water to accumulate below, is dangerous.

(*f*) When using treated wood, pre-fabrication is desirable before the application of treatment; *if possible, all surfaces subsequently exposed by cutting or puncturing must be brush treated with preservative.*

(*g*) Always remove shavings, soil, and debris from surface concrete, together with pieces of wood employed during excavation and shuttering used for concrete work.

Preventive Measures against Dry-Wood Termites, Powder-Post and Other Beetles.

The dry-wood termite cannot be controlled by construction measures, as it does not need contact with the ground. The best preventive measures are :—

(*a*) Use only all-heart timbers of proved resistance to termite attack (*vide* table in Appendix I).

(*b*) Use timber which has been properly treated with an effective preservative.

Preventive Measures against Subterranean Termites.

1. *Timbers in Contact with the Ground.*

(*a*) Use only timber of proved resistance to termite attack (*vide* table in Appendix I).

(*b*) Use timber which has been properly treated with an effective preservative.

2. *Timbers not in Contact with the Ground.*

It is important to remember that subterranean termites enter buildings by means of cracks in concrete or masonry walls, through timbers, or by means of their tubes built over these materials. They may also build their

tubes along the surface of pipes, fence-posts, trellises, etc., and thereby gain entrance. Proper methods of construction can in the case of simple buildings prohibit entirely the entrance of subterranenan termites.

The following is a summary of some of the measures recommended in the U.S.A. :—.

(1) Build in a manner which will prevent the entry of termites from the soil.

(2) The foundations of buildings should be of concrete, masonry laid in cement, or of properly treated timber, or of timber of proved resistance to termites.

(3) Provide all foundation walls, posts, or piers with metal termite shields below the wood to be protected, consisting of a non-corroding sheet of metal projecting horizontally at least 2 inches, and then turned downwards for an additional 2 inches at an angle of 45°; all joints should be locked, and preferably soldered with corners made tight. Bed all wood posts, plates, etc., on a newly laid mortar cap above the foundation.

(4) Where pipes extend through concrete floors or masonry walls, a tight joint must be secured about them with cement mortar. Pipes extending into the ground should be protected by a downward-sloping collar soldered to the pipes about 18 inches above ground with a horizontal projection of at least 3 inches at their lower edge.

(5) The soil beneath and around the building should be provided with adequate drainage.

(6) Debris and shuttering should be cleared from under floors, porches, and around foundation walls, and not used as fill in place of earth. Remove all tree-stumps and roots under and around the building.

(7) Fences, trellises, etc., should be kept at least 2 inches away from the building.

In the case of buildings raised off the ground, it is a sound practice not to join the steps to the building, but to separate the two by a gap of 2 inches. Regular inspections to look for runways are desirable.

Methods of Repair.

Attack by Fungus.

(1) Remove and burn all infected material, and replace with properly treated timber.

(2) If not too costly, eliminate the conditions of damp causing the fungal attack.

Attack by Dry-Wood Termites.

(1) All structurally unsafe materials should be removed and burnt.

(2) In the case of wood left *in situ*, poison dusts, such as Paris Green, may be blown into openings made into the galleries of the termites, and the openings then plugged. As the termites lick each other and also consume dead members of the colony, the whole colony may be eventually destroyed.

(3) Alternatively, the wood may be fumigated by placing a wad of cotton soaked in carbon bisulphide over an opening to the galleries and covered by a double sheet of wet newspaper made to adhere closely to the wood.

(4) Infected furniture may be exposed to lethal temperatures (120–150° F.), or fumigated in an air-tight container with some fumigant such as carbon bisulphide.

The use of arsenical-dust poisons in dwelling-houses is not recommended, owing to the ability of certain fungi, which may be present in the termite galleries, to absorb arsenic and later emit it in the form of diethylarsine, which is a highly toxic gas, dangerous to human beings.

Attack by Subterranean Termites.

(1) All avenues between the ground and the material to be protected must be closed by placing barriers of metal, concrete, or treated wood. All termites cut off from the ground will die.

(2) All structurally unsound wood must be removed and burnt.

(3) The ground may be poisoned at all points where runways emerge; poisons recommended by authorities are a 10 per cent. solution of sodium arsenite; lead arsenate at the rate of 5 lb. per 1000 sq. ft.; a mixture of 1 part creosote to 3 parts kerosine; and carbon bisulphide emulsion.

(4) Introduce poison dusts or fumigants, as in the case of dry-wood termites, into termite galleries in wood which must be left in contact with the ground.

Wood Preservation.

In the foregoing description of measures to be adopted for the prevention of fungus and termite attack frequent mention has been made of the use of wood properly treated with effective preservatives. The use of wood preservatives is, unfortunately, almost non-existent in Trinidad; when wood preservatives *are* used, they are often so unintelligently applied as completely to nullify their value and waste the money spent on them.

The first important point to remember in connection with wood preservation is that satisfactory results depend on the maintenance of an *unbroken* coating of preservative; as soon as the coating is broken at any point, untreated wood is exposed to insect or fungus attack and the remaining coating is rendered useless, since attack can progress behind it. Consequently timbers exposed to splitting from atmospheric conditions or to mechanical injury require a far deeper penetration of preservative than timbers which, after being placed in position, are not so exposed.

The second important point to remember is that the penetration of the preservative into seasoned timber is far greater than into green timber, and into sapwood than heartwood. Generally speaking, penetration is better with softwoods than hardwoods.

Thus the adoption of proper wood preservation enables the confident use of timber containing sapwood and of non-durable species of timber, which, untreated, are prone to rapid decay or destruction.

Methods of Treatment.

No preservative confers complete immunity indefinitely, and, provided that a preservative of proved efficacy is used, the method of treatment is, subject to certain considerations referred to later, more important than the choice of preservative.

There are five methods of treatment—viz., brushing, spraying, dipping, "open tank," and pressure, of which the first is the least efficacious and the last the most.

Brush Treatment has the advantage of extreme simplicity, but penetration is usually very superficial. *At least* two coats should be given, the second being applied after the first is dry. In the case of creosote type preservatives, better penetration is secured if the liquid is applied hot.

Spraying has much the same effectiveness as brushing.

Dipping in either hot or cold preservative is better than brushing, but again only light penetration is secured.

All the above methods should, if long life is aimed at, be confined to timbers which are to be protected from exposure to atmospheric conditions and to mechanical injury, and to repairing the damage done to treated timber by subsequent fabrication.

The Open-tank Treatment is far superior to brushing, spraying, or dipping; provided the wood is seasoned, good penetration is secured, except in the case of timbers which are highly resistant to impregnation. Such timbers, however, may prove refractory even to pressure treatment.

The theory of the method is as follows: Air-dry wood contains minute air spaces, which may occupy up to nearly 50 per cent. of its volume. When air-dry wood is immersed in a liquid, which is then heated, the air expands, and some of it is driven out of the wood. When the liquid is allowed to cool, the air left in the wood contracts again, forming a partial vacuum, and the liquid is drawn into the wood. In the case of green wood, the spaces, which in air-dry wood are filled with air, contain water; the expansion of this water under heat is relatively small, and consequently but little of the preservative will be drawn into the wood during the cooling period.

The plant required for this method is simple and inexpensive, and does not require technically skilled operators. It consists of a treating-tank made of iron or mild steel ¼ inch thick, of dimensions suitable for the types of timber to be treated; a useful sized tank would be 20 feet × 4 feet × 4 feet. Treating-tanks should be deep and narrow, rather than wide and shallow, in order to minimize evaporation losses.

The treating-tank must be provided with some means of heating, such as a system of steam coils leading from a boiler, or a flue running the whole length beneath, in which a fire can be lit; alternatively, it may be electrically heated.

The treating-tank should also be provided with steel girders at the bottom on which the timber can rest, and thus allow circulation of the creosote. It is desirable also to provide wooden covers with which to close the tank and minimize evaporation. A drain-plug should be provided in the bottom of the tank to allow emptying for cleaning or other purposes.

The tank is usually partly sunk in a pit with a space around the sides to

allow free circulation of air for cooling and access for inspection. It may be provided with a storage tank and pump, or merely a platform on which drums of the preservative can be placed, and from which the liquid can run direct into the tank.

At one end of the tank a draining-table should be constructed large enough to hold any load coming from the treating-tank. The table can drain back into the tank or into a drain leading to the storage tank.

A simple form of gantry and lifting-winch should run the entire length of the plant to facilitate the handling of the loads of timber. The laths are usually held in some form of cradle, which is lowered into the tank for treatment. The timber is stacked in the cradle with strips of wood ½ inch thick between each layer to ensure free circulation of the liquid, and heavy weights of old iron are placed on the top to ensure complete submersion of the load. A thermometer completes the equipment.

The method of operation is as follows: the cradle containing the load of timber is lowered into the tank, and the preservative is then heated to a temperature of 180–220° F. This temperature is maintained for varying periods, according to the size of timber being treated and the amount of absorption desired. The preservative is then allowed to cool, *care being taken that the timber is completely submerged during the cooling period, which is also the absorption period*; the timber is then removed and allowed to drain. The heating period usually occupies about 4 hours, and thus the operator need only be in attendance for that period, as there is nothing further for him to do after turning off the heat. The absorption of the preservative can be regulated by lengthening the heating period.

The process can be speeded up by installing a battery of two tanks, one to contain the hot preservative, and the other the cold. With this plant the timber can be transferred, after a sufficient heating period, from the hot tank to the cold, whereupon a new load can be placed in the hot tank.

For the butt treatment of posts and poles—*i.e.*, the treatment only of that part which is in contact with and near the ground—a very simple plant can be constructed, consisting of an oil drum provided with a brick furnace and a flue.

It may be of interest to record that in the case of railway sleepers made from fourteen different species of local hardwoods, an average absorption of 4 lb. of creosote per cubic foot was obtained by this method; a longer seasoning period would have produced even better results.

Pressure Treatment is the most effective of all methods of applying preservatives: it is usually considered economical only where considerable quantities of lumber have to be treated, as it involves a somewhat elaborate and expensive plant combined with skilled operation. In brief, the plant consists of a storage tank, a treating-tank or cylinder, vacuum and pressure pumps, and a steam-raising plant.

In the "full-cell" process the timber is placed in the treating-tank, and a vacuum is applied to draw as much air as possible from the cells of the wood. The preservative is then run into the tank, and a pressure of 100–175 lb. per square inch is applied to force the preservative into the wood. As a result of the preliminary vacuum treatment the preservative flows into, and remains in, the wood cells.

In the "empty-cell" process the timber is subjected to a preliminary

pressure before the application of the preservative, and the latter is then forced into the wood under pressure. When the pressure is released, the expanding air in the cells forces the preservative out of the cells, leaving only the cell walls coated with the preservative. A final drying vacuum is then applied.

Pre-treatment.—In the case of timbers which are resistant to impregnation—*e.g.*, douglas fir—and where good penetration is essential, a pre-treatment by incision is often practised. The timber is passed under a revolving drum fitted with regularly spaced knives, which incise gashes into the timber of the required depth. This operation assists subsequent penetration.

Wood Preservatives.

Preservatives can be broadly classed into three main groups: Oil preservatives, water-soluble salts, and solvent type preservatives.

Oil Preservatives.

The most important of these are coal-tar and creosote.

Coal-tar is not very satisfactory: it does not penetrate wood, but forms a surface coating which may eventually assist decay by sealing up the moisture in the wood.

By creosote as a wood preservative is understood a coal-tar creosote oil; it is a distillate of coal-tar produced by high-temperature carbonization of bituminous coal. It should comply with the specification of the British Standards Institution (see Appendix II).

A half-and-half mixture of creosote with diesel oil is just as effective as pure creosote, from the preservation point of view, penetrates wood better, and is considerably cheaper in view of the low cost of the diesel oil.

The advantages of creosote are its extreme toxicity and its permanence in the wood even when exposed to rain; its disadvantages are its smell, its dark colour, its liability to creep onto and stain adjoining material, the fact that it cannot be painted over, and, being in liquid form, its bulk.

Its excellence as a preservative is unrivalled, and where its disadvantages do not matter—*e.g.*, for exterior timbers in contact with the ground, such as posts, poles, sleepers, etc.—a better choice cannot be made.

There are various proprietary preservatives prepared from tar oil, which are efficient, cleaner, and of less pungent smell than ordinary creosote; they are, however, more costly.

Water-Soluble Salts.

The salts chiefly concerned are copper chromate, copper sulphate, sodium fluoride, mercuric chloride, zinc chloride, zinc sulphate, and zinc meta-arsenite. Several proprietary brands of preservatives employ one or more of these salts, and in some an attempt has been made to fix the preservative principles in the wood so that they cannot be leached out.

The advantages of water-soluble salts, particularly for buildings, are: their relatively small bulk in solid form, their lack of smell and (usually) colour, and the facts that they do not creep and stain adjoining material, and can be painted over. In addition, zinc chloride to some extent increases the fire-resistance of wood. Their disadvantage lies in their

liability to be leached out by rain and that some of them have a corrosive effect on metals, necessitating a wooden tank for treatment. This does not apply to zinc chloride, which, incidentally, has a good record in Panama.

Solvent-Type Preservatives.

The solvent-type preservative consists of a toxic chemical dissolved in a volatile oil or spirit solvent, which, after treatment, evaporates and leaves the toxic chemical in the wood. The toxic chemicals used include metallic salts of organic acids such as naphthenic and oleic acids; phenols such as β-naphthol, chlorinated phenols and chlorinated hydrocarbons, such as chlorinated naphthalene. It may be of interest to record that local tests are now being conducted on timber treated locally by the open-tank method with copper and mercuric naphthanates produced by Trinidad Leaseholds, Ltd., with, so far, most encouraging results.

The advantages of this type of preservative are their high toxicity and good penetration; the disadvantages are the high cost, and, in some cases, their inflammability prior to being applied to the wood. The open-tank treatment was, however, applied without danger in the case of the copper and mercuric naphthanates referred to above.

Choice of Preservative and Method of Treatment.

From the foregoing brief account of wood preservatives and the methods of their application, it is clear that the choice of preservative and method of treatment will vary according to a number of factors *e.g.* :—

(1) The species of timber—its natural durability and its resistance or otherwise to impregnation.

(2) The use to which the timber is to be put, and the consequent degree of danger to which it will be exposed. Clearly timbers in contact with the ground and exposed to the weather require a deeper and more thorough impregnation than interior timbers.

(3) The length of life which it is desired that the timber should have.

(4) The cost of the method of treatment and of the preservative relative to the value of the increase of life obtained.

(5) The annual amount of timber utilized for new works.

(6) The amount of capital available for the erection of plant.

In view of these varying factors, it is not possible to lay down hard-and-fast rules to govern the choice of preservative and method of treatment for all local timber-consuming industries, but the following recommendations are put forward as a guide, which may be altered to suit individual circumstances :—

1. *Timbers other than for Dwelling-houses, Offices, etc.*

Type of timber.	Preservative.	Method of treatment.
(*a*) Timbers in contact with the ground and/or exposed to the weather and/or abrasion—*e.g.*, posts, poles, bridge-timbers, etc.	Half-and-half mixture of creosote and diesel oil.	Pressure or open tank.
(*b*) Other timbers.	Half-and-half mixture of creosote and diesel oil.	Open tank, dipping, spraying, or brushing.

2. *Timbers for Dwelling-houses, Offices, etc.*

(*a*) Timbers in contact with the ground and/or exposed to the weather and/or abrasion.	Water-soluble salts—*e.g.*, zinc chloride or reliable proprietary preservative.	Pressure or open tank, followed by applications of paint.
(*b*) Interior timbers.	Water-soluble salts—*e.g.*, zinc chloride or reliable proprietary preservative.	Open tank, dipping, spraying, or brushing, followed by applications of paint where indicated.

Conclusion.

The adoption of the simple preventive methods of construction described in this paper, combined with the use of wood which has been properly treated with a reliable preservative, would unquestionably result in the minimization of the decay and destruction of timber, in a considerable reduction of expense incurred in repairs and replacements, and in a much-needed economy of timber consumption.

Summary.

The need for economizing the use of timber by the prolongation of its life is stressed; a brief account of fungi, termites, and other insect pests is given; preventive and control measures against these agents of decay and destruction are described, and information as to wood preservatives and the methods of their application is presented.

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Appendix I.

Resistance of Local and Imported Timbers to Fungi and Termites.

Species.	To fungi.	To termites.
Acurel.	Very susceptible.	Fairly resistant.
Balata.	Very resistant.	Very resistant.
Blackheart.	Fairly resistant.	Susceptible.
Bois lisette.	Very susceptible.	Fairly resistant.
Bois mulatre.	Resistant.	Very resistant.
Cajuca.	Very susceptible.	Very susceptible.
Douglas fir.	Fairly resistant.	Very susceptible.
Fiddlewood, black.	Susceptible.	Fairly resistant.
Fiddlewood, white.	Fairly resistant.	Fairly resistant.
Figuier.	Very susceptible.	Very susceptible.
Galba.	Susceptible.	Fairly resistant.
Gommier viande biche.	Susceptible.	Very susceptible.
Guatecare.	Resistant.	Very resistant.
Hogplum.	Very susceptible.	Very susceptible.
Laylay.	Very susceptible.	Very susceptible.
Mahoe.	Very susceptible.	Very susceptible.
Mangrove, red.	Fairly resistant.	Susceptible.
Mangue, yellow.	Resistant.	Susceptible.
Mora.	Susceptible.	Resistant.
Milkwood.	Very susceptible.	Very susceptible.
Olivier, white.	Fairly resistant.	Fairly resistant.
Olivier, yellow.	Fairly resistant.	Fairly resistant.
Pitch pine (all heart, unbled).	Very resistant.	Resistant.
Poui.	Very resistant.	Very resistant.
Redwood.	Resistant.	Very resistant.
Sandbox.	Fairly resistant.	Susceptible.
Sardine.	Very susceptible.	Very susceptible.
Serrette.	Susceptible.	Resistant.
Tapana.	Susceptible.	Resistant.
Toporite.	Very susceptible.	Very susceptible.
Wild coffee.	Very susceptible.	Susceptible.
Wild chataigne.	Very susceptible.	Very susceptible.

N.B.—(1) In the above table five classes of description are used—viz., resistant, very resistant, fairly resistant, susceptible, very susceptible.

(2) The table was compiled from durability tests on untreated timber specimens conducted by the Forest Department in collaboration with the Imperial College of Tropical Agriculture from 1937 onwards.

Appendix II.

Very large quantities of timbers are cut each year by petroleum companies in the course of oil exploitation, of which no use is made whatsoever. Attention is, therefore, directed to the following suggestions :—

Suggestions for the Increased Use of Local Timber Cut for Clearing Purposes by Petroleum Companies.

(1) Non-durable softwoods, such as mahoe, cajuca, wild chataigne, etc., could provide useful boards and planks, if the latter were seasoned and then given a preservative treatment.

(2) Unseasoned boards of local woods could be used for such purposes as shuttering for concrete, boxing for slush-pits, etc., instead of imported timber.

(3) Scantlings of local woods can be used after a short period of case-hardening, provided they are not re-cut into smaller dimensions. Scantling which is not quite straight can usually be keyed into position.

(4) The air-seasoning of boards and planks is a shorter and simpler process than appears to be generally understood; full particulars of the correct method can be obtained from the Forest Department.

Appendix III.

Summary of Tests on Timber Treated with Preservatives, to date September 1941.

(a) *General Durability Trials.*

Species.	Date put in ground.	Treatment.	Remarks.
1. Acurel	March April 1937	50–50 Creosote and diesel oil mixture, open tank.	Still sound after 4 years. Untreated, all destroyed in 2 years.
2. Blackheart			Still sound after 4 years. Untreated, 50% destroyed in 3 years.
3. Bois lissette			Still sound after 4 years. Untreated, all destroyed in 2 years.
4. Bois mulatre			Still sound after 4 years. Untreated, 30% destroyed in 3 years.
5. Cajuca			Still sound after 4 years. Untreated, all destroyed in under 1 year.
6. Figuier			One destroyed by fungus, rest sound. Untreated, mostly destroyed in 2 years.
7. Black fiddlewood			Slight fungus attack, 1 destroyed. Untreated, 80% destroyed in 3 years.
8. White fiddlewood			Slight fungus attack, 3 destroyed. Untreated, 80% destroyed in 3 years.
9. Galba			Sound. Untreated, 90% destroyed in 3 years.
10. Gommier viande biche			All heavily attacked by termites. 19 destroyed. Untreated, 80% destroyed in 2 years.
11. Guatecare			Fungus on a few. Untreated, wood is resistant.
12. Red mangrove			All heavily attacked by termites, 3 destroyed. Untreated, 60% destroyed in 3 years.
13. Laylay			Sound. Untreated, all destroyed in under 1 year.
14. Mahoe			Some attacked, 8 destroyed. Untreated, all destroyed after 1 year.
15. Hogplum			Sound. Untreated, all destroyed in under 1 year.
16. Yellow mangue			Majority attacked by termites, only 1 destroyed. Untreated, 30% destroyed in 3 years.
17. Milkwood			Sound. Untreated, all destroyed in 1 year.
18. White olivier			Fungus on a few. Untreated, nearly 50% destroyed after 3 years.
19. Yellow olivier			Sound. Untreated, nearly 50% destroyed after 3 years.
20. Sandbox			Sound. Untreated, 75% destroyed in 3 years.
21. Sardine			Majority attacked, 2 destroyed. Untreated, all destroyed after 1 year.
22. Sorrette			Slightly damaged. Untreated, all destroyed in 2 years.
23. Tapana			Sound. Untreated, all destroyed in 3 years.
24. Teak (10 years old)			Sound after 2 years. Untreated, susceptible to damage.

APPENDIX III.—*Continued.*

Species.	Date put in ground.	Treatment.	Remarks.
25. Toporite	March April 1937	50–50 Creosote and diesel oil mixture, open tank.	Slight damage. Untreated, all destroyed in 1 year.
26. Wild coffee			Slight damage. Untreated, 90% destroyed in 3 years.
27. Wild chataigne			Sound. Untreated, all destroyed in 1 year.
28. Balata			Sound. Untreated, few destroyed in 4 years, but all attacked.
29. Poui			Sound. Untreated, few destroyed in 4 years, but all attacked.
30. Pitch pine			Sound. Untreated, fairly resistant, 20% destroyed in 3 years.
31. Douglas fir			Sound. Untreated, all destroyed in 3 years.
32. Calif. redwood			Sound. Untreated, 50% destroyed in 3 years.
33. Mora	Oct. 1939		Still sound after 2 years. 60% untreated pieces destroyed after 3 years.
34. W/red cedar	Oct. 1939		Still sound after 2 years. 30% untreated pieces destroyed after 2 years.

N.B.—The few treated pieces which have been badly attacked, had resisted impregnation; penetration of the creosote was poor.

(b) *Special Trials.*

Species.	No. of samples.	Date put in ground.	Treatment.	Remarks.
Laylay	20	June 1939	Copnap 15%, open tank.	Still sound.
White pine	10	Sept. 1939	2½% Copper naphthenate, open tank.	
	10		5%	
	10		7½%	
	12		10%	
	10		15%	
	22		20%	
	10		NoRot, open tank, 9–41 lb. per cu. ft.	All still sound after 2 years. 20 untreated pieces all destroyed after 2 years.
	10		NoRot, soaked 24 hours, 3–13 lb. per cu. ft.	
	10		Seekay soaked 24 hours, 3–7 lb. per cu. ft.	
	10		Gas oil, open tank.	
	10		0·43% Mercuric naphthenate, open tank.	
	10		0·875%	
	10		1·3%	
	10		1·75%	
	10		3·5%	
Chir pine	12	Apr. 1937	Treated with "Ascu" in India.	Still sound after 4½ years. 12 untreated pieces destroyed in under 1 year.
Teak fence-posts	7	Oct. 1939	Creosote/diesel oil, open tank.	Still sound after 2 years.

DISCUSSION.

Mr. L. A. Bushe (A.T.O.L.) congratulated the author, and said he did not think they were in a position to question the results of research carried out by the Forest Department, or the principles of wood preservation. They might, however, argue that, whereas Mr. Brooks was interested in preservation, perhaps at any cost, they in the Oil Industry had to consider the cost. The author, as a forestry-trained man, took a long view, and it seemed to him that they also had to take a similar view with regard to the use of timber, and the author had made some very pointed remarks on the unintelligent way in which preservatives had been used in Trinidad. He expected every one would find it difficult to extract costs of replacement of timber in buildings, but they could accept the fact, which was given in many textbooks, that preservation of timbers (railway sleepers, for example) did multiply the life by something like three or four times, using creosote or tar oil.

There was a very appropriate mention made in the paper about the greater use of local timber in war-time, and he was sure they could use a great many of the trees which were felled in the course of their operations and which at present were simply allowed to rot.

Mr. Bushe then declared the paper open for discussion.

Mr. G. Mardall (T.L.L.) said it would be interesting to know what percentage of the 1,400,000 feet of timber mentioned in the paper as being cut out in the course of oilfield development during 1940 was usable for building and other purposes.

There was also a point which Mr. Brooks had not mentioned in his paper, and which had come to their notice recently with the curtailment of the use of galvanized iron—namely, the question of using shingles for roofing—and he wished to know what were the author's recommendations for the best type of timber for the purpose of shingles, and also whether treatment was essential to make it resistant to fungus attack, if it was liable to such attack.

On the question of solid floors, instead of the standard and somewhat elaborate form of protection when putting wooden flooring on the top of concrete on the ground, about 5 or 6 years ago T.L.L. had laid down a number of concrete floors which they had covered with wood, and had found it perfectly satisfactory to cover the concrete with a layer of pitch before putting the timber on, and so far experienced no trouble with these floors.

He was also interested to know the rate of penetration of termites once they started in timber such as posts or flooring.

Mr. J. D. Fullerton (A.T.O.L.) referred to the pressure treatment described on page 71 of the paper, in which mention was made of pressures of 100–175 lb. per square inch, and enquired whether that limit was imposed by economic reasons, and if such pressure was considered advisable for all types of wood. In other words, would 500 lb. pressure be advantageous or not, supposing that such pressure could be as readily applied.

Mr. G. H. Scott (A.T.O.L.) asked if the author could say anything about the theories advanced by Dr. Rudger of Cardiff, who attacked the idea of fungus rot and believed in the idea of inorganic infiltration as the cause of primary decay. His writings had led to a great amount of controversy, but his latest paper, he believed, vindicated the theory that the effect of such inorganic substances as calcium bicarbonate was fully as important as the extent of attack by fungus.

For instance, in the example given by Mr. Mardall where they had actually placed residuum or pitch on concrete and applied their wood floor to it, they had not had any appreciable decay. This may have been the result of the wood being removed from the infiltration of calcium bicarbonate. A source of inorganic attack could be where wood penetrated into the concrete on which a structure was built. He believed that woods contain a certain amount of iron and calcium, and that ionization in the wood could set up wood decay. It was arguable whether dry rot was primarily due to inorganic infiltration, but, judging from examples cited by Dr. Rudger, it did, in many instances, play an important rôle.

MR. L. K. WHITE (T.P.D.) remarked that on page 65 of the paper it was stated that subterranean termites, if cut off from the ground, would die, but did that mean they would actually die if cut off from the ground, or would they be able perhaps to get the necessary moisture from household water supplies? If so, it would seem that cutting off of an infected house would not guarantee death to the termites.

He seemed to remember having seen or heard that people used to burn the ends of posts before putting them into the ground, in order to prevent rot or decay, and would like to know if that was a sound practice and, if so, what was the principle involved.

MR. BUSHE observed that quite recently a pamphlet had come into his possession advertising a proprietary preservative, and putting forward a theory which the author had not touched on, and which was called the "Osmotic Pressure Treatment." This meant that the preservative, which was applied cold in a liquid state and before the timber was seasoned, was absorbed by the moisture in the wood, and it was claimed that very deep penetration was obtained. The cost of the treatment was given as something between ½ c. and 1 c. per square foot of cover, but he did not know if the author would consider that cheap or expensive.

MR. BROOKS remarked that he had had an uneasy feeling before he came to the meeting that he would be faced with some rather difficult questions! Firstly, as to the question of cost, he definitely had not run away from it, but at the present time it was extremely difficult to give any accurate costs, owing to rising prices. Creosote treatment before the war was extremely cheap, particularly when the creosote was mixed with local diesel oil, as even an absorption of 6 or 7 lb. to the cubic foot added on a very small cost to the article concerned. The cost of creosote was now, however, higher than pre-war.

There was also the question of the different sites in which the timber was going to be used and the relative cost of the structure itself. If, for example, one was going to the trouble of building a fairly large and heavy pitch-pine bridge, much of the pitch-pine coming to Trinidad to-day being about 50 per cent. sapwood, the normal life would be about 5 years, and to double the life by treatment of the timber would be an economic proposition. On the other hand, to impregnate roof-timbers under pressure treatment would be a waste of money. The question of the economic cost was a question of the relative life of the untreated and treated timber coupled with the length of life desired.

Roughly speaking, buildings could be termite-proofed at a relatively small cost, say 1–2 per cent. of the initial cost in the case of subterranean termites, which meant mainly structural measures, and about 10 per cent. of such cost in the case of dry-wood termites, which necessitated impregnation of the timber.

The cost of replacement had also to be considered in the case of railway sleepers; an original untreated sleeper other than balata or poui might cost about $2.40, and would last about 3 years. If treated with hot and cold treatment it might last 12 years, and this would save the re-laying of three sets of sleepers during that period. Such treatment would cost perhaps $1 extra per sleeper, and was thus clearly economic.

What the actual cost was to-day of going in for preservative treatment was very difficult to say, as it would depend on what method of treatment and what preservative was used and how much capital was sunk in the plant.

He thought there was very little doubt that the ordinary cheap processes that did not involve much capital expense, the use of water-soluble salt preservatives for timbers that were not going to be exposed, and a mixture of creosote and diesel oil (which before the war could be prepared for something like 15 c. per gallon) for exposed timbers, was economic, provided a certain length of life was wanted out of the timber.

The initial outlay in the case of hot and cold treatment was very small, and if the life of the timber by this treatment was going to be multiplied several times, and as most other countries, even before the war, never dreamed of putting in outdoor timbers without treatment, the question of economics for that type of work surely answered itself.

With regard to Mr. Mardall's questions, the figure of 1,400,000 feet mentioned represented inevitable clearing by oil companies for their well locations, roads, etc., and the bulk of the trees were just left to rot on the ground, although some of the better-class trees might be removed by oilfield contractors. He had ventured to suggest in the Appendix to his paper that, in a time of crisis like the present, when pitch-

pine might not go on being *ad lib.* for the rest of the war, some of these woods that they despised to-day might be used, even untreated, where the question of durability did not arise.

As for shingles, for long life they certainly required some form of treatment. With the hot and cold method of treatment they could be saturated with creosote, but at least they required some form of treatment as used in British Guiana in the case of wallaba shingles.

On the question of the solid floor with a layer of pitch, the results might have been due to luck, but 5 years was not a particularly long period. Good pitch-pine, even under bad conditions, might well last that period. With reference to the illustrations he had shown of this kind of floor, the note in the textbook was that none of these forms was completely satisfactory, and the author advised against any form of solid floor. The generally accepted principle, so far as fungus prevention was concerned, was that it was difficult completely to exclude air, and it was therefore preferable to provide free air circulation.

As to the rate of destruction by termites, this entirely depended on the species of termite and the type of wood. For example, in India there were termites which people asserted would eat out the legs of a bed in the course of a night, provided the legs were made of a non-resistant species of wood.

In Trinidad the dry-wood termites were a comparatively slow-working species, but with certain non-resistant woods, such as douglas fir, a piece of 2 inch × 2 inch could be reduced completely unsound in 6 months by subterranean termites. On the other hand, termites appeared to be cunning engineers, and he did not think they had ever been known of themselves to cause a structure to fall down, but they would weaken it so much that a high wind or earthquake could bring it down. A good example of this was the cottage in the Government House grounds, the frame of which was so termite-riddled that in places one could poke one's finger right through, yet it has been up for 50 or 60 years, and appeared to be kept together only by the paint and the termites themselves holding hands! The rate of damage would entirely depend on the species of termite and on the species of wood, and whether it was all heart or contained a lot of sapwood.

With regard to Mr. Fullerton's question about pressure, he thought the pressures given were just the result of experience. Obviously one did not want to put more creosote into the wood than would be effective, and excessive pressure might injure the cellular structure of the wood. The "full-cell" pressure method left unnecessary creosote in the wood, while the "empty-cell" pressure just left a coating of creosote on the cell walls. If an absorption of 12 lb. per cubic foot was enough to give satisfactory results for extreme conditions, it would be a waste of creosote and money to put 24 lb.

Mr. G. H. Scott had, he feared, gone further into the subject of the possibilities of damage to wood by inorganic attack than he himself had. There had been a great deal of research recently as to exactly how fungus did attack wood and what were the effects of concrete and other materials on wood, but the fact remained that there were certain basic laws with regard to fungus, which at any rate did the main damage, and the principle remained that fungus must have certain conditions in which to grow. If conditions were suitable the fungus was going to do the damage.

With regard to Mr. White's question on sources of moisture for termites, he had, when reading the paper, added to the statement that subterranean termites would die if their connection with the ground was permanently severed, the proviso that they found no other source of moisture.

The charring of wood posts was effective through changing the material nature of the wood and turning it into charcoal, thus destroying the food material for fungi. It was a good method of prolonging the life of poles, but did not last very long generally, owing to insufficient depth of charred surface.

Mr. Bushe had mentioned the "osmotic-pressure" method, and he would like to know the source of this. There were many different proprietary preservatives and, some of them made very optimistic claims. For example, he had received an advertisement for a process whereby one just cut a ring round the living tree and poured the preservative in, which then not only stopped all insect attack and preserved the wood for ever, but even seasoned the wood! Any new method of treatment or type of preservative which was both cheap and efficacious would soon be generally adopted.

In the meantime it was safer to rely on standardized methods and preservatives, and to take with a grain of salt any over-optimistic claims of new methods and preservatives which had not yet been adopted as standard general practice.

In Trinidad to-day there was an enormous amount of damage done by termites that could be avoided by simple construction methods. House after house was just being riddled by termites for want of simple precautions.

He was not trying to push local wood, but was talking about imported wood, which arrived in Trinidad already seasoned. By intelligent application of preservatives one could lengthen the life of that wood, whether for outside or indoor use, and as it was war-time, he thought it should be introduced now, and if that were done he believed the practice would never be abandoned afterwards.

Mr. Bushe, thanking the author for his paper, said it seemed to him that this was possibly one of the comparatively few subjects upon which the views of Government and of the oil industry might well coincide. The Conservator of Forests thought they ought to use wood preservatives, and it was left to them to see that they did so in an intelligent manner.